Photovoltaic Solar Technology

Creating Electricity from Sunlight

Solar installation workers mount PV panels on a private home. These panels generate clean, pollution-free electricity and can reduce or eliminate monthly electricity bills. In 2008, over 16,000 residential systems were installed, with an average size of just under 5 kilowatts (kW). (Photo – NREL)

Overview

Photovoltaic (PV) technologies directly convert energy from sunlight into electricity. Sunlight strikes the semiconductor material and releases electrons from their atomic bonds, producing an electric current. PV panels contain no moving parts and generally last twenty years or more with minimal maintenance. Homeowners can install PV panels to reduce or eliminate their monthly electricity bills, and utilities can build large "farms" of PV panels to provide pollution-free electricity to their customers. PV electricity output peaks mid-day when the sun is at its highest point in the sky, and can offset expensive electricity produced when daily demand is greatest.

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Semiconductors: The Foundation of PV

Semiconductors are used in most electronic products, including computer chips, audio amplifiers, temperature sensors and solar cells. Traditionally, PV cells are made using various forms of silicon (Si), but companies are now manufacturing cells using a wide variety of semiconductor materials, each of which lend themselves to different applications. Two of these qualities are particularly important: the *absorption coefficient* – which refers to how easily light is absorbed by the material, and the *band-gap* – which determines how efficiently light energy from different parts of the solar spectrum release the electrons from their atomic bonds.

- Crystalline Silicon (c-Si)

  C-Si cells were first commercialized by Bell Labs in the 1950s, and are traditionally manufactured by slicing high-grade (>99.99 percent purity) silicon into thin wafers, roughly as thick as several human hairs. Mono-crystalline silicon solar cells offer higher efficiencies but are more difficult to manufacture. Poly-crystalline silicon cells have generally lower efficiencies but are cheaper and easier to manufacture.
- Thin-Film

  Thin-film solar cells are the main focus of many leading-edge PV manufacturers and researchers. These cells are manufactured by applying very thin layers of semiconductor material to inexpensive materials such as glass, plastic or metal. Thin-film semiconductors absorb light more easily than c-Si, so they require less semiconductor material but tend to be less efficient at energy conversion. They are also much simpler and less costly to manufacture. Examples include cadmium telluride (CdTe) and copper-indium-gallium-diselenide (CIGS).
- Multi-junction

  Also called *cascade* or *tandem* cells, *multi-junction solar cells* are the highest-efficiency solar cells currently available. These cells work by combining two or more types of semiconductor material with staggered band-gaps, allowing each to capture a different range of the solar spectrum. The result is a cell with much higher efficiency than any single-material PV cell. These types of cells are expensive to manufacture, and are used when weight and efficiency are at a premium, such as satellites, high-performance solar-powered vehicles, in military applications, and for concentrating PV (CPV).

Types of Thin-film Semiconductors

- Gallium Arsenide (GaAs) – High efficiency, high cost, resistant to heat and radiation. Used in concentrator cells and high-efficiency applications such as satellites and solar vehicles.
- Copper Indium Gallium Diselenide (CIGS) – Cells using these materials are manufactured using several alloy variants and are used to create flexible, high-efficiency thin-film panels.
- Cadmium Telluride (CdTe) – An inexpensive, efficient thin-film material with a simple manufacturing process. Well-suited to mass production.
- Amorphous Silicon (a-Si) – Inexpensive, low-efficiency material used for large systems and in low-power applications such as watches and calculators.

At 25 MW peak output, the DeSoto Next Generation Solar Energy Center in DeSoto County Florida is currently the largest PV installation in the United States. The facility came online in 2009 and generates over 42,000 megawatt-hours of electricity each year. (Photo—Florida Power & Light)

Photovoltaic Panel Configuration

- ***Flat-Plate Solar Panels***
  The most common type of solar panel. These panels absorb both direct sunlight and diffuse sunlight reflected from clouds and objects on the ground.
- ***Concentrating Photovoltaic***
  This is a specialized type of solar panel which uses mirrors or lenses to focus high concentrations of direct sunlight onto high-efficiency solar cells. Since concentrating panels cannot absorb diffuse light, they are typically only used in areas with high levels of sunlight such as the Southwest United States. In order to maintain focus, CPV employs *tracking systems,* allowing them to follow the sun's path as it moves across the sky.
- ***Tracking systems***
  These can be either single-axis – which track the sun throughout the day – or dual-axis, which also adjust to the sun's elevation in the sky from season to season. (Tracking systems are also occasionally used for flat-plate systems.) Depending on conditions, tracking systems can add 25 percent or more to the total electrical output of a solar energy system.
- ***Balance of System Components***
  The term 'balance of system' refers to specialized electrical wiring, racks and mounting components for PV panels. A PV system requires a way to match the power it is generating to the power being drawn, either by electrical devices, household appliances or the electric grid. This is done by an *inverter* or *power conditioner,* which converts the DC power generated by solar panels into AC power which can be used by household appliances or fed into the electric grid. Some systems also contain batteries to provide independent power when there is no sunlight.

About the Solar Energy Industries Association

Established in 1974, SEIA is the national trade association of the solar energy industry. As the voice of the industry, SEIA works to make solar a mainstream and significant energy source by expanding markets, removing market barriers, strengthening the industry and educating the public on the benefits of solar energy.

For a footnoted version of this factsheet and more information, please visit www.seia.org.